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Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

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Carothers and Nylon

ON October 16, at Oddenino's Restaurant, members of the Institute of Plastics crowded to listen to Dr. G. Stafford Whitby, of the Government Chemical Laboratories at Teddington, tell the story of nylon. The occasion was a very special one, since not only is the story one of the most fascinating in plastics history, but also because Dr. Whitby stands in a very interesting situation regarding it. He was a close friend of Dr. Carothers, the American chemist whose amazing work, in the short space of nine years, resulted in the vast number of plastics which can be included under the heading of nylon. Just as there is a large section of chemical science known in industry as the chemistry of dyestuffs, so there will be one day a chemistry of nylon as a subject matter in chemical schools. Dr. Whitby was closely in touch with all the work of Carothers and, indeed, has been largely responsible for bringing the collected information before the British public. That Dr. Carothers died so young is a major tragedy to the whole world of science.

We have often referred to the analogy between the work of the famous German chemist, Emil Fischer, and that of Carothers. The former, whose researches fascinated the chemical world of 30 and 40 years ago, broke down protein matter, the nitrogen-containing substance in the living cell, into very simple compounds called amino-acids (that is organic acids containing an ammonia group). By working backwards he attempted to build up protein-like molecules, but only succeeded in producing "half-way" substances of about 1,200 molecular weight (very low in comparison with most plastics). They were not polymers and were not plastics

While no doubt Carothers tried to continue Fischer's work, his researches soon departed from it. He used somewhat similar materials, but his main object was to get high molecular weight polymers. One of the most important reactions is that between a compound containing two amino groups and one containing two acid groups, but since the changes can be rung with these subsidiary groups the number of resulting compounds possible is enormous. On polymerization they all give the plastic materials known under the generic name of nylon, and as Dr. Whitby remarked, the molecule can be "tailored" to suit our requirements.

He also told us that, judging from the patents, one of the most important of the nylons is made from hexamethylene diamine and adipic acid. This fact is of tremendous significance to this country, for adipic acid is made from phenol (carbolic acid) by hydrogenation and treatment with nitric acid, breaking down the phenol ring to make a straight chain. Furthermore, hexamethylene diamine is made from adipic acid.

While both can also be made from petroleum, it is of the first importance that they can be made from phenol, since the coal-tar industry in this country is so well developed and since we have no natural petroleum. Without doubt we seem to be approaching a time when the number of polymer plastics made from coal tar will rival that of dyestuffs also made from the same source.

Dr. Whitby finished his fascinating story by showing us many samples of nylon in the form of spun fibre, bristles and sutures and told us that the tensile strength of the thread was about that of mild steel! The future of nylon will indeed be an interesting one.

Petroleum v. Coal

THE foregoing notes on the raw materials for making nylon add to the importance of Mr. Brajnikoff's article on p. 226 of this issue. His notes may appear somewhat complicated (the avoidance of chemical names is almost impossible in an article of this nature), but the significance of them stands out clearly, and it is upon such information that industrialists and, indeed, Governments may well base their reactions to certain movements.

To develop the problem of nylon still further the following appears:—Both the chemicals mentioned, that is, adipic acid and hexamethylene diamine, contain 6 carbon atoms. The figure 6 means a lot to this country, for it means that we can use phenol (which also contains 6 carbon atoms) to make them both, and phenol is plentiful here. But we cannot make a compound containing 5 carbon atoms or less from phenol (although theoretically it is possible), nor can we easily

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make a "straight chain" 7-atom compound, say, from cresol, which is also made from coal tar.

Petroleum and natural gas, on the other hand, are much more versatile, for in the crude state they contain between them a very wide number of hydrocarbons, ranging from methane gas, with 1 carbon atom, up to solids containing 20 and more carbon atoms. And from many of them we can obtain some chemical that is useful for further manufacture into plastics and other compounds. Thus nylon may be produced in America from petroleum.

It is true from the above that the possession of large coal fields and the technique to exploit them is a condition heartily to be desired by nations. We are extremely fortunate in this respect. The possession of indigenous petroleum and natural gases is even more important, and we are not so fortunate in this respect. But so long as we can obtain them in our Empire or can control the output of certain wells by friendly agreement and the means of importing it, there is little to fear for our industries.

BRITISH EXPORTS AND GERMAN PROPAGANDA.—At the request of the Ministry of Information, the Secretary of the British Plastics Federation has written the following note which will be given wide publicity in the United States. We know our friends in the U.S.A. will accept it as a true statement of the functions of the British plastics industry in war-time.

"Information has been received from various leading industrialists in the United States of America indicating that propaganda is current there, probably from unfriendly sources, that the Plastics Industry and other trades in Great Britain are still producing unreasonable quantities of non-essential articles of the domestic and fancy-goods types and, furthermore, are seeking to take advantage of the present situation by entering into competition with the U.S.A. in certain export markets.

"The purpose of these insinuations, which undoubtedly emanate from Germany, is, of course, to mislead the American people into thinking that British industry is not taking the war seriously and yet is asking the United States for the maximum amount of assistance.

"*There is no truth whatever in this propaganda.* As far as the British Plastics Industry is concerned, the large majority of its members are engaged almost, if not entirely, on vital work for the Government and Service departments, particularly the Ministry of Aircraft Production. So important are these firms to the national effort that the Ministry of Labour and National Service recently decided to apply the Essential Work Order to the moulding powder manufacturing, moulding, manipulating and fabricating branches of the plastics trade. The aircraft industry has for long fully realized the possibilities of plastics materials and products, and many of the leading aircraft companies in this country and abroad have actively co-operated in their development. These range from transparent materials for cockpit and turret screens and landing-light covers down to moulded sections for wings and interior panels.

"The uses to which the Plastics Industry's raw materials are devoted are strictly supervised by the Plastics Control of the Ministry of Supply, to which body applications for licences have to be submitted; and those firms which, prior to the war, specialized in the manufacture of fancy articles will be found to have switched over completely and perforce to Government and other essential contracts. It is a significant feature of this war that labour simply will not carry out work which is not of national importance, and any plastics manufacturer who endeavoured to continue with the production of non-essentials would not only find it impossible to obtain the necessary raw material but would be unable to retain his employees. It is becoming increasingly difficult for moulders to obtain licences to employ powders for anything except Government and Service needs; and there is a further control exercised by the Limitation of Supplies Order, whereby, in the case of plastics fancy and household goods, manufacturers can only produce 25 per cent. of their pre-war output over a given period.

"The Plastics Export Group, which was inaugurated in May, 1940, by the British Plastics Federation—the trade organization of the industry—at the direct request of the Board of Trade, produced a catalogue of mouldings suitable for export which is without parallel in this country. Over 400 articles were illustrated and their descriptions were given in English, French, Spanish and Portuguese. The British Plastics Industry is concentrating so entirely, however, on the national war effort that the comprehensive export programme initiated by the Group has had to be completely curtailed and placed in 'cold storage' until after the war. Fifteen thousand copies of the catalogue and price list intended for distribution overseas to specially appointed joint agents throughout the world now lie idle and unused.

"The export of British moulding powders has also been severely restricted and a licence has first of all to be obtained from the Plastics Control. Under this arrangement, orders from abroad can only be accepted when full proof has been given and confirmed by the Ministry of Supply in the country concerned that the powder is required for Great Britain's war effort.

"I feel confident that the above remarks are typical in principle of all other industries in this country, and indicate, I am sure, that Great Britain has mobilized her resources to the full in her unshakable determination to bring peace and prosperity back to Europe."

SYNTHETIC RUBBER AND POST-WAR RESEARCH.—At a meeting of the Society of Chemical Industry, at Manchester, on October 3, Mr. S. A. Brazier, M.Sc., F.I.C., the well-known rubber chemist, gave an address entitled "Industrial Chemistry and Post-war Conditions." He prefaced his remarks by telling of the great advances that had been made in the use of research on industrial problems, and gave as illustration and comparison the methods of German and American production of Buna and neoprene respectively. Under the Nazi regime the production of the former was accelerated to make the nation independent of imported natural rubber and the work was heavily subsidized. In contrast, neoprene was made by Du Pont Co. on a purely commercial basis, but recently other American concerns had started manufacture of butadiene synthetics which may produce 50,000 to 100,000 tons a year in the U.S.A. It has been stated that 100,000 tons of Buna will be made this year.

In addition, other products have been made with technical superiority over alternative materials. Some of these have been manufactured for political reasons, so that the speaker visualized a complicated situation when the war ended, as considerable disturbance in the economic position of important countries had to be anticipated.

Mr. Brazier then emphasized that these remarkable developments were only made by the expenditure of large amounts of money on research and that we in this country must be prepared to carry out research on a much more comprehensive scale than is done at present. He indicated two methods of approach: one, the compulsory national organization of research such as had been undertaken in Germany, and, the second, the improvement in the relationship between the research carried out by industry, that undertaken by the industrial research associations and the research work done at our universities. It was essential that more fundamental work should be undertaken by our research associations, whose income was grossly inadequate for the scale required by industry. The author considered the financing of these associations a national matter—an investment by the nation to secure its industrial continuity.

Plastics and the Prefabrication of Buildings

As a continuation of his notes in the October issue, the author discusses the new trend of building and architecture and the probable place of plastics in it

By
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THE architect or building technician is hardly likely to spend time and study on plastic materials or attempt to familiarize himself with the simple but tricky techniques of moulding, casting, extruding or impregnating, etc., if he is not firstly convinced that new objectives are thus attainable. It is essential, therefore, that these new goals should be stated clearly. By isolating the relevant problems it is possible to suggest fruitful researches to the plastic manufacturer who intends to enter this promising and lucrative building market.

Synthetic building materials may be presented to the architect by the plastic industry in three ways:—

(a) As an individual component offered as a substitute or alternative to the same building part formerly made in wood, metal or fireclay. For example, a plastic window, a plastic door or a plastic bath.

(b) As a new technique to be used in conjunction with existing brick and concrete structures. For example, brick walls with plastic floors and partitions or concrete walls with plastic external or internal finishings.

(c) As entire prefabricated structures delivered direct from the factory in large sections ready for the minimum assembly operations on the site.

While all three methods will be exploited it is by the last-named procedure (c) that greatest progress can be made. By complete prefabrication the fullest use is made of the remarkable lightness in weight of synthetic plastic compounds, whereas in the case of (a) or (b) the plastic is used in conjunction with heavy materials which do not lend themselves to prefabrication and prevent the maximum exploitation of the virtues of the material. Furthermore, the plastic part must therefore compete in cost with, perhaps, a lower-priced metal component without economic advantage of prefabrication to offset the difference.

Prefabrication as an Ideal

The key to the future of building lies in the word "prefabrication." This ideal has long been in the minds of architects, but the conventional materials of building have seldom permitted any appreciable degree of success. Perhaps the nearest approach to a factory technique has been the precasting of concrete blocks, but in this as in brick wall construction, external cement rendering, internal plasterwork or papering and painting still requires time-wasting site operations. Again, the mere dead load of precast concrete blocks has meant only a very limited degree of prefabrication owing to heavy transport and handling costs.

Prefabrication of buildings is no longer of mere academic interest as was largely the case before the outbreak of war. Widespread bombing of open towns has been added to a serious housing shortage to create a building crisis unparalleled in history. It is safe to predict that for many years after the war building schemes and methods will be judged by the degree to which they lend themselves to speed of manufacture and assembly. The prefabrication of homes has made giant strides in America. "Your house delivered in a package" is the slogan of one company. Information has now been received that Dr. Ley, the leader of the German Labour Front, has given instructions that immediate steps be taken to put the manufacture of houses and light structures on a complete prefabrication basis, not necessarily for post-war needs only, but for urgent conditions arising in war-time. This would seem to indicate that some form of standardized house of a temporary or intermediate type is already developing on German drawing boards under the realistic conditions imposed by R.A.F. bombing. One realizes the essential sanity of making provision for building parts, mass-produced, in such a way that supplies can be rushed at a moment's notice to the points where emergency conditions have arisen. It is, of course, well known that similar proposals have been put forward in this country prior to the news that our enemies were working on similar lines. The Building Plastics Research Corporation, Ltd., submitted schemes of temporary wartime plastic houses to the Government in collaboration with their consulting architect, Mr. Sam Bunton, A.R.I.A.S., M.Inst.R.A.

Wall Surfaces

In a previous article, I pointed out certain difficulties with which the architect was confronted in giving consideration to plastics for wall surfacing. The plastics manufacturer appears to have concentrated almost exclusively on the production of highly glazed sheeting, the disadvantages of which, apart from those already pointed out, are high cost, tendency to warp, and the extreme difficulty of fixing the sheets to a structural frame without the necessity of using cover-strips. It will be readily understood that external appearance of a building, especially of the domestic type, would, in nine cases out of ten, be destroyed by splitting it up into irregular panels. It is, of course, possible to design a panelled structure of pleasing appearance, good proportion and simplicity, but those who have made the attempt know that this ideal, however simple it may look at first sight, is difficult of attainment. One reason is that, by association of ideas from tradition, a panelled exterior invariably gives the impression of a temporary structure. The functional or scientific mind is inclined to dismiss such arbitrary considerations, but as the æsthetic outlook of the public stands at present the manufacturer who ignores these prejudices when launching a new product may be committing "harakiri." If one attempts to avoid fixing by means of cover-strips and resorts to butt-jointing new difficulties are created. First, the sheets must be thickened and therefore become expensive. To avoid external screw-heads, the fixing must be arranged from behind, and

this leads to some form of internal wall-tie which, in turn, raises complications when fixing these ties to the sheet itself. Again, butt-jointing the plastic sheets would tend to emphasize any warp which might take place through dimensional change under varying conditions of temperature or humidity.

It is not suggested or implied that the production of flat sheeting will be useless as a technique for permanent building, but it is worth while to point out that these apparently niggling considerations become magnified immediately one descends from the realm of airy generalization to the field of practical application. In the case of internal wall sheeting, the position is further complicated by the necessity of obtaining qualities of insulation, good nail-holding properties and resistance to condensation. Frankly, plastic sheeting as developed to date by most manufacturers shows insufficient promise of fulfilling these conditions. It has, however, the merits of cleanliness and hygiene.

These are the "bottlenecks" in the application of plastics to building, but the statement of the problems does not imply that these widely differing functions are irreconcilable. On the contrary, we have found that the boundary of knowledge is the starting-off point for the research worker and these varying factors will be co-related in the production of the ideal plastic building sheet.

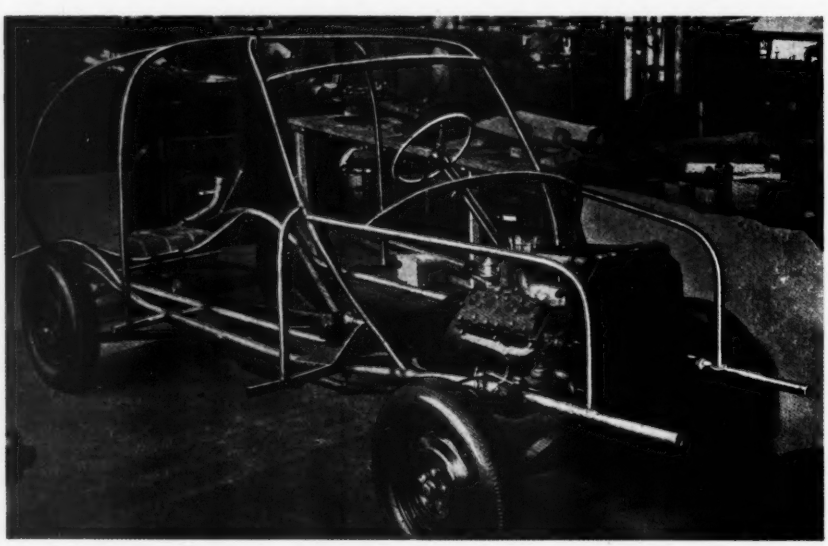
It should be remembered that pressed sheeting is not necessarily the most promising method of approach to the problem of wall surfacing. An alternative technique is that of applying the plastic in the form of a paste to existing building blocks. Research along these lines has been carried out almost unnoticed by the plastics industry. Let us take, for instance, the problem of surfacing a concrete block. It has been established that concrete is vulnerable to attack from atmospheric acids and salts causing corrosion and decay. Water absorption also is the cause of innumerable difficulties in building structures and the market is flooded with a wide variety of waterproofing compounds, most of which are either useless or expensive, or both. Again, the difficulties of providing decorative surfaces to concrete are well known. Moisture absorption and frost are primary causes of crazing, cracking or flaking, and most cement renderings are subject to these difficulties plus discoloration within a few years.

It is more than a guess to predict that these problems will be solved by the plastics industry in collaboration with building experts. Synthetic compounds can be applied to the faces of prefabricated blocks to give finishes which are both decorative and weather resisting. The colour range will be magnificent and the texture as desired. The surfaces will have all the advantages already enumerated for plastics, and it will even be possible for the housewife, if she so desires, to change her colour scheme without having to scrap expensive plastic veneers or panels. A new skin can be applied on the job, using the compound. The operation will be analogous to replastering, and while the procedure would not at present stand economic comparison with plastering, the necessity for renewal would not arise unless on the whim of the occupant who wishes a new colour scheme. It should also be considered that expensive pressing plant would not be required as in the case of plastic sheeting, and any desired area could be covered as against the 8 ft. by 4 ft. of heated platens.

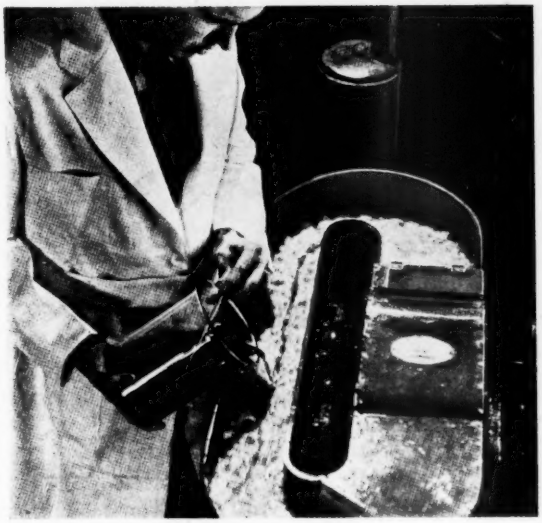
The new age of building prefabrication will demand that products along the lines suggested be developed immediately and a wide new range of finishes presented to the architect. There is no lack of evidence that the plastics industry is able and willing to undertake these new and exciting problems.

FORD'S PLASTIC CAR

WE should imagine that as soon as the first plastic ash-tray appeared on the early motorcar (circa 1925) the man in the street began to translate this movement into terms of moulding whole cars. It was the plastics manufacturer who rather ridiculed the idea. This is not so strange as it seems on the surface, for the plastics technician sees all the difficulties, while the man in the street, blessed only with imagination, knows none of them. And difficulties are apt to blind those who are too much in the game. However, the process continued steadily—plastic knobs and winding handles, door handles, driving wheels, window fillets, glove compartments and facia boards. Then the ghosted car of methyl methacrylate resin



The frame of the new plastic car. Note the revolutionary design of welded tube on which the plastic panels are clamped.



Mixing the resin with wood fibre in an experimental paper beater.

The preformed panel after it has been removed by suction on the preformer.

for exhibition purposes. Certainly the motor industry was becoming interested in plastics.

The first whisperings of plastic bodies came from abroad, the very idea being pooh-poohed by the Great Moguls of the automobile industry here.

The Auto-Union, in Germany, worked on two lines of thought—the body made of impregnated laminated veneers and the body of moulded units; the first moulded door was shown at the Leipzig Fair in March, 1939. From its outward appearance it seemed to be made of a pressed resin-emulsion impregnated flock or a resin-fabric "powder."

For more than three years rumours have come to us that Ford has been interested in the plastic car. His interest lies not merely in plastics but also in the possible combination of plastics with agricultural products. Hence his early experiments with soya bean-phenol formaldehyde resins (rear luggage doors, accelerators, pedals, etc., have been made), and with the use of vegetable fibres as fillers for more normal phenolic resins.

In our last issue we reproduced a photograph of the first Ford plastic car, with some data concerning it. Through the courtesy of "Modern Plastics," of New York, we are now able to publish three additional photographs of the actual car frame and two others of the process of fabricating the moulded panels.

As we have previously indicated, the car has been designed, from the beginning, especially for plastics. Thus the framework itself is made of welded steel tubes designed to allow the fastening of plastic panels by means of clamps and screws. This special tubular structure is stated to be stronger than the orthodox design, offering high protection in the event of the car rolling over. The fixing of the panels to the framework is rapid and simple, while a self-hardening cement is used to make the jointings invisible. Doubtless this adds enormously to the appearance of the body.

How the Panels Are Made

As for the panels themselves, they appear to be fashioned in a manner analogous to that which we have already indicated. Phenolic resin, probably in the form of an emulsion, is poured on to wood fibre in a pulpy state in a paper-beating machine. Flax or hemp may be introduced also to improve the strength. While the resin-pulp is still in suspension it is sucked on to a preform by vacuum and most of the water is removed. On release of the vacuum the preformed shape is dropped, then passes on to a drying chamber, and is

The finished plastic car. Note the clean streamlined appearance and the absence of fenders.

finally pressed in a hydraulic press. The pressure here is extremely low, being of the order of 50 lb. per sq. in. While this does not give a very dense material the strength is very satisfactory.

As we have previously indicated, the car with the plastic body weighs 2,000 lb., against 3,000 lb. for one of comparable size in steel. This makes possible the use of a smaller engine with consequent saving to the user in petrol, cost of licence, etc. Moreover, it is anticipated that there will be a considerable saving as a result of fewer fabricating and finishing operations. According to "Modern Plastics," Mr. Ford has commented on the fact that whereas the relatively simple rear compartment door when made of steel requires seven stamping operations, the same panel in plastics requires only two.

The first car was painted to obtain colour, but there seems little doubt that the darker colours can be incorporated in the plastic material.

Ideas—

By the EDITOR

Let Us Spray

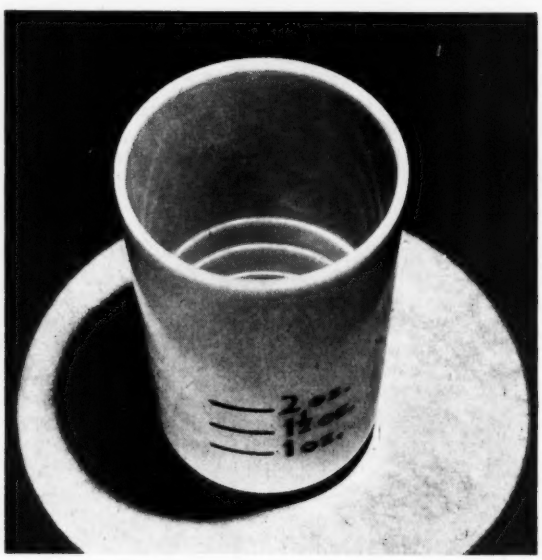
The strange-looking apparatus in the accompanying photograph is neither an electric iron nor an electric bed warming pan. It is an intelligent use of plastics for the spraying of disinfectant fluids and the like. I do not know how it works, but, presumably, the lower half contains the fluid and a motor blows air bubbles through it and squirts a spray into the air. The large container eliminates the necessity for running backwards and forwards, filling the usual type of hand pump such as is used in cinemas, or for carrying a pail containing the main stock. The advantages of using moulded plastics are rather obvious here. Lightness is

of paramount importance, resistance to oils and chemicals almost equally so; general cleanliness of appearance, smooth design and electrical resistance complete the reason for making plastics unsurpassed for the purpose. This spraying apparatus is, of course, in a sense, merely an improvement on the well-known Vermorel spray, which we used in the last war against poison gas and which vine-growers in France and other countries use to spray vines with copper sulphate solution. They are normally of metal, copper, I believe. Heavy in weight, readily corroded by chemical solutions, metal could easily be replaced by better-designed plastics for these larger jobs. However, the Vermorel sprayer is not electrically driven as this seems to be.

The present device can be moulded in a variety of plastics; Durez resins, the products of Durez Plastics and Chemicals, Inc., of Tonawanda, N.Y., have been used.

For Those In Peril

Here at last is something of war-time British manufacture about which the authorities will not mind letting the enemy know. The Ministry of War Transport has brought out a new order that ships' lifeboats and rafts are to carry special emergency rations, and included in these there must be a graduated tumbler with which to distribute rations of water to the occupants. Glass has its obvious demerits and the moulded Beetle tumbler shown here every advantage.



The Ministry of War Transport has approved it and it is made graduated inside by steps indicating 1 oz., 1½ oz. and 2 oz., these quantities being indicated on the outside of the tumbler by printing. It is extremely stoutly built. By accident I dropped it on concrete without the slightest effect. Who says the non-breakable quality of well-made plastics is a myth? Streetly Manufacturing Co. mould the tumblers for Duncan, Wallet and Co., of Fenchurch Street, London, who distribute them to shipowners and ship chandlers.

Plastics and Powder Metallurgy

By H. W. GREENWOOD

Being further notes on the incorporation of metal powders in plastics and the changes wrought thereby. In this issue the author deals with applications in the decorative and electrical fields

THE name plastic is indicative of the outstanding property of the group of materials which we so designate. In the search for a comprehensive and particular definition of a metal the lack of plasticity in metals has been suggested as helping to differentiate them from other matter. Hence, in thinking of plastics and metals we note that here is one more case of plastics having a valuable property which metals either do not possess or, at best, possess to a very restricted degree.

It is one of the advantages of powder metallurgy that it permits of the fabrication of metal articles by methods which are quite impossible with metal in the mass. An example is the making of compacts by cold-pressing methods. It has to be admitted that one of the drawbacks to cold-pressing, and a very severe limitation to the extent to which it can be exploited, lies in the fact that it is practically impossible to develop any appreciable degree of plasticity with metal powder. What you can do is to compress it so that all air space between the separate particles is squeezed out and eliminated, and the metal closely compacted into a solid mass. There is, however, no plastic flow as such, and as a result the type of compact, or perhaps one could say the shape of compact, is limited to those shapes which can be produced by direct pressure applied to the whole face of the compact. In other words, one can use only simple dies in which the pressure exerted is applied directly to the entire cross-section of the piece being compacted. This is in marked contrast to what one can do with a really plastic material, and one at once contrasts the limitations encountered in metal powders with the possibilities that exist in moulding plastics.

Plastics and Rubber Technique Compared

This leads to the further reflection that, notwithstanding these possibilities, there are many directions in which the strength or the heat or electrical conductivity of moulded plastics leave much to be desired, and so the question arises as to the possibility of combining plastics and powder metals to overcome the shortcomings of both these groups of materials. Up to the present progress in this direction has not passed much beyond the tentative or experimental stage, yet there can be little doubt that there are tremendous possibilities awaiting development. Nor are they confined solely to the advantages to be obtained by the mechanical mixing of two dissimilar products and the blending of their properties. We can turn to the rubber industry once again for a lead, just as we did with the benefits of incorporating metal powders into materials that come into moving contact with one another. It has been found that the addition of metal powder to rubber has conferred benefits in the direction of increased durability and improvement in the curing or vulcanization of the rubber, this latter through improved heat transfer. In the case of rubber, the metal powder used was pure aluminium, this being unaffected by the sulphur used in vulcanization, copper or similar powders easily affected by sulphur being completely ruled out. The plastic technician will at once realize that he is not confronted with this disability and therefore his choice of metals can obviously be much wider. This is important for æsthetic, as well as other, reasons. It means that the whole range of copper and bronze powders are available in addition to aluminium and other white metals, and it is quite unnecessary to stress their decorative value. It is already known that plastics act as insulators to metal particles enclosed in them and preserve them from attack or corrosion by outside or atmospheric influences.

This means that, judged only from the decorative point of view, there are numerous possibilities available. There are other and, perhaps, more important considerations. The addition of metal powder may be expected to add materially to the strength of the moulded part, and in the cases where flake powders are used, and it may well be that they will predominate, there will be something analogous to a laminated filling effect. Then, too, the notably improved heat conductivity of the mass is likely to have an appreciable effect in the time of the cure. This may prove worth studying from the point of view of mass production. It will obviously have no importance in the case of very small articles or those produced only in comparatively small numbers. So far we have been generalizing: thinking in terms of articles of everyday use, which the plastic industry turns out in large numbers and which would be improved, both in mechanical properties and in appearance, by the addition of metallic powders. Herein would lie the justification for the extra cost.

Changing the Electrical Properties of Plastics

Let us now consider some further possibilities. It is quite well known that the electrical or, rather, the dielectric properties of plastics, particularly the phenolics, are notably influenced by the fillers used, and in the past there has sometimes been dissatisfaction with the low insulating qualities of certain plastics, which in the great majority of cases have been traced to improper filling, inefficient curing and, as a basal cause, the excessive cutting of price. On the whole, both the plastic and the electrical industries have come to think of plastics in terms of insulators, but by combining plastics with metal powders there is no reason why plastic conductors should not exist. This has been hinted at in an earlier article; now it can be considered in a little more detail. The question will at once be asked whether it is a general or a specific use as conductors that is envisaged. At present very definitely specific uses are best considered. Think, for example, of the very many forms of electric-current collector brushes which are required to-day, and think, too, of the way in which the earlier wholly carbon brushes have become now combined copper-powder-carbon brushes or collectors. To the plastic technician it is instructive to note that the reason for the use of the copper powder in the first instance was to improve the conductivity of carbon brushes without sacrificing the

lubricating value of the graphite. It was soon found that when the copper content was sufficiently high the mechanical strength of the brush was notably increased and the necessity for an additional bonding material was eliminated. There are many cases where collectors for electrical current, where low current densities are involved, could be fashioned from plastics and where, possibly, use could be made of the known fact that where flake metal powder, copper in particular, is used in mixtures which are to be pressed, and where pressure is applied in a direction at right angles to that in which current is to flow, an orienting of copper particles takes place, with the result that such a pressing or brush has a notably enhanced conductivity in the required direction. The further question of the necessity for some lubricant might well be met, either by the incorporation of graphite or by the use of some lubricating metal, such as lead or tin, remembering always that we are talking of small collector brushes, which are not used for heavy currents nor for high speeds and pressures. Possibilities of the character just discussed will be best considered jointly by plastic technicians and electrical engineers, and the first step should be the drawing up of a statement of exactly what is required and of how the wants are filled at the moment. So far the objects we have been considering have had an even distribution of components throughout the mass. That is, we could look upon the copper, for example, as replacing in part at least other fillers and being evenly distributed throughout the plastic. There is, however, no reason why we should impose any such restriction on ourselves. There is no reason why we should not think of built-up plastic masses in which we have a heavily metallized sector or segment protected above and below by segments of unmetallized plastic. Such built-up materials need not be restricted to layer-like bodies; we can think of a central cylindrical component let into a square or rectangular component and, indeed, the possible variants are legion. Such combinations could make simultaneous use of the insulating properties of pure plastic and the conducting properties of metal-impregnated plastic, and at once numerous possibilities leap to the mind. One of the problems in which such combinations might well play a part is that of quickly dissipating static electrical charges on vehicles and, above all, aircraft, a matter which is not yet quite satisfactorily settled. These are but a few of the directions in which use can be made of the widely contrasted properties peculiar to metals and plastics, and which can be most easily exploited by using intelligently conceived combinations of metal powder and plastic, so that specific requirements are fulfilled by taking advantage of properties, either single or combined, which the combination of the two groups of materials can afford.

Foamed Synthetic Glue for Plywood

A modification of urea-formaldehyde glues by Aero Research, Ltd., overcomes the difficulty of using them for thin veneers

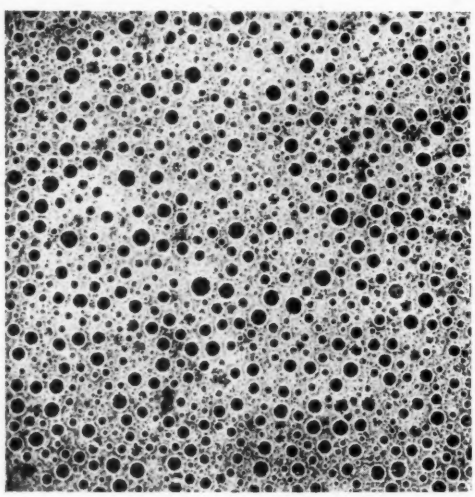


Photo-micrograph of foamed glue (× 120 approx.).

THE development and increasing use made of synthetic adhesives has been a feature of plastics progress during the past few years. This is especially interesting because glue manufacture is one of the oldest arts, and it seems probable that synthetic adhesives will revolutionize it as surely as synthetic dyes and synthetic paints have revolutionized well-established industries.

Enormous quantities of natural glue are, of course, still used in the woodworking industries, but there is one important branch—the manufacture of plywood—where, in this country at least, natural glues have been completely supplanted by synthetic ones.

Plywood is made to one of two specifications, either D.T.D.427 or B.S.S. 5.V.3, requiring resistance to three hours' immersion in water at 60 degrees C. (140 degrees F.) and 100 degrees C. (212 degrees F.) respectively. At present urea-formaldehyde resins are used for D.T.D.427 plywood and Tego or Plybond film (paper impregnated with a phenol-formaldehyde resin and used in a dry state) for the 5.V.3 plywood. On the whole, the phenol-formaldehyde resins are more water resistant than the urea-formaldehyde resins (though these can be given sufficient water resistance to meet the three hours' boiling test of specification B.S.S. 5.V.3 by the use of certain modifying agents), but they need higher pressures and temperatures to set them than do the urea-formaldehyde resins. The ability to set urea-formaldehyde resins at room temperatures is not at present of importance in plywood manufacture, as all the plywood made in this country is made in hot presses.

A New Development

Although modified urea-formaldehyde glues meet the requirements of B.S.S. 5.V.3, they cannot be used in the manufacture of very thin plywood because of the swelling caused in the thin veneers by the wet glue, and because of the penetration that takes place after subsequent pressing. The phenol-formaldehyde film type of glue is, of course, immune from these troubles.

To meet this difficulty and, at the same time, to reduce costs, Messrs. Aero Research, Ltd., have introduced in the last few months a foamed modified urea-formaldehyde glue which in many respects combines the advantage of liquid and of dry-film glues with the added advantage of low cost.

The idea behind this process is that, provided penetration of the glue into the veneers is obviated, only a very thin film of glue is needed to make good joints, and the amount of glue applied by any ordinary means (glue spreaders or brushes) is in excess of the optimum amount. By using the glue in the form of a foam of about the same consistency as the lather produced from shaving soap, an extremely thin uniform spread is obtained in terms of pounds of glue per sq. ft., although the glue layer has an appreciable thickness. Actually, the volume of the glue is about doubled by a special beater machine before it is poured into the glue spreader. Under ordinary factory conditions, without taking any special precautions it is possible to get a spread of 1.35 lb. of glue per 100 sq. ft.

This foamed-up Aerolite glue is known as Aerolite F.67 and gives plywood meeting the requirements of specification 5.V.3. Because of the nature of the foam, it can be used with thin veneers without producing excessive wrinkling or causing overlaps in the cores. The foam is allowed to dry on the veneers after it has come through the rollers of the glue spreader. It does this very quickly and, in fact, the film of foam will be found to be dry by the time that the veneers have been assembled for pressing.

The press temperature required is 90 degrees C., so that steam-heated presses are unnecessary and the older type of press, so common in this country, with hot-water heating, can be used. The use of pressing temperatures below 100 degrees C. obviates any risk of over-heating.

From a national point of view, this ingenious process is of great interest because it enables two important materials—urea and formaldehyde—to go twice as far.

Messrs. J. M. Steel and Co., Ltd., of Kern House, 36-38, Kingsway, London, W.C.2, are the sole distributors of Aerolite glue.

A New Adhesive for

· HOLLOW MOULDINGS

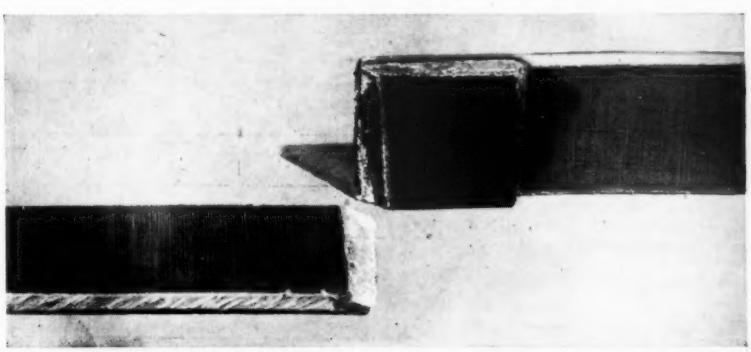
A hollow wheel made in two parts and joined with Ardux synthetic glue.

THE plastic wheel shown in the photograph is lighter than water and obviously is hollow, since solid phenolic mouldings are about 30 per cent. heavier than water. It is also obvious that the moulding is made in two halves to get the hollowness and so save weight. The remarkable point is that great and permanent adhesion between the two parts has been obtained, since the gluing together of two pieces of cured phenolic or urea resin has been one of the great problems of the past.

The new glue has been named Ardux and is yet another product of Aero Research, Ltd. In a letter to us about this material, Dr. H. de Bruyne, who is the well-known director of the company, says that "Ardux makes it possible for the first time to get really good joints between moulded or laminated synthetic resins and it should be a boon to those who wish to make up instrument panels in laminated (and, therefore, non-mouldable) resins; all the bushes, bezels and the like can be cemented on with a strength as good as the parent material."

Ardux is a liquid mixture that is applied to the surfaces to be joined which are then clamped together in an ordinary carpenter's clamp and stoved to 140 degrees C. No preparation of the surfaces, such as brushing or scratching, is necessary. Ardux has already been used for two years, but it has only just been released from the secret list.

Already many exciting but secret things have been done with the material. Each of us can think of many applications in peace-time.



A breaking test to show the strength of Ardux. The laminated sheet has broken and not the glue.

Weatherproofing Cellulose Acetate

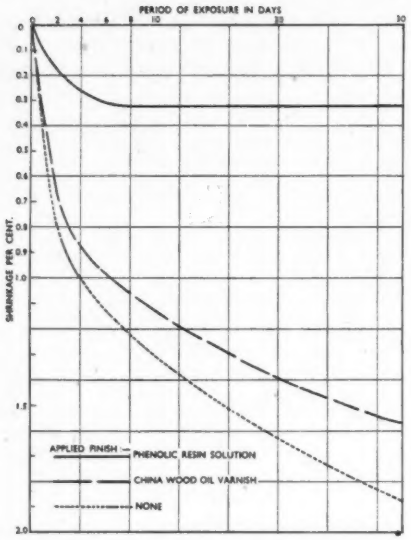


Fig. 1.—Shrinkage in length, cellulose-acetate test pieces, with and without applied finish, exposed to dry heat at 60°C.

A Description of a New Phenolic-resin Solution for Coating Fabricated Components of Acetate

By
E. E. HALLS

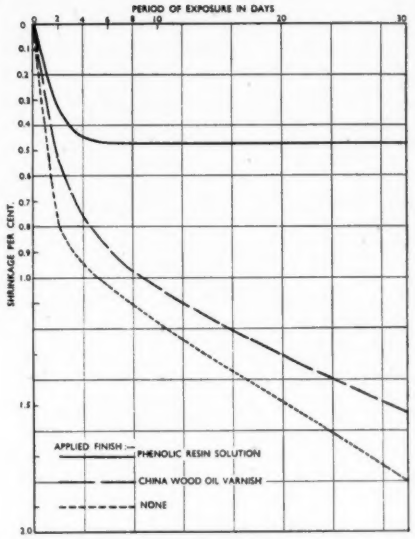


Fig. 2.—Shrinkage in width, cellulose-acetate test pieces, with and without applied finish, exposed to dry heat at 60°C.

WITH the wide variety of plastic types, and grades within the same type, that are to-day available to the engineer, it is nearly always practicable to select a raw material to suit all the conditions obtaining. It must be admitted, however, without reflection upon the plastics industry that important instances arise when this satisfactory state of affairs does not occur and some compromise has to be effected. Usually, the shortcoming is not caused by failure to locate a plastic to meet the service conditions, but rather inability to fulfil the production requirements of fabrication. Again, this in turn generally devolves upon such problems as size or shape of the article, the quantity involved, production costs entailed in a particular mode of fabrication, and the fact that tooling costs for a specific method of utilizing the ideal material are prohibitive for the number of components required. The position therefore arises that weatherproof plastics are readily obtainable to withstand fluctuating conditions of temperature and humidity, as well as to provide requirements of mechanical strength, electrical quality, etc., and although these raw materials are securable in all forms, e.g., sheet and rod and moulding powder, it may not be practicable to take advantage of them. When a compromise is accepted specific basic properties cannot be forgone, and those to which greater latitude is given than is really desirable have to be corrected by other means.

The foregoing explains in some measure the requirement of weatherproofing cellulose acetate. This material is inert and stable in the general sense and, in fact, weather-resisting for numerous applications. It is

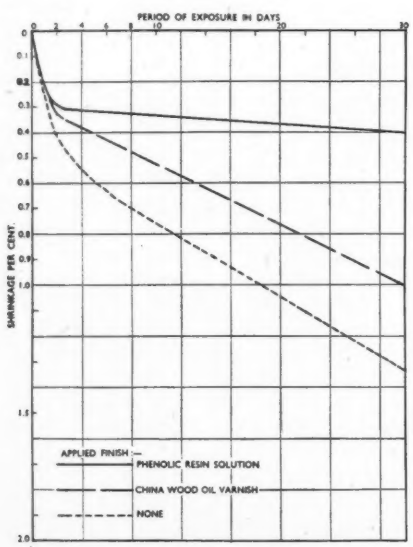
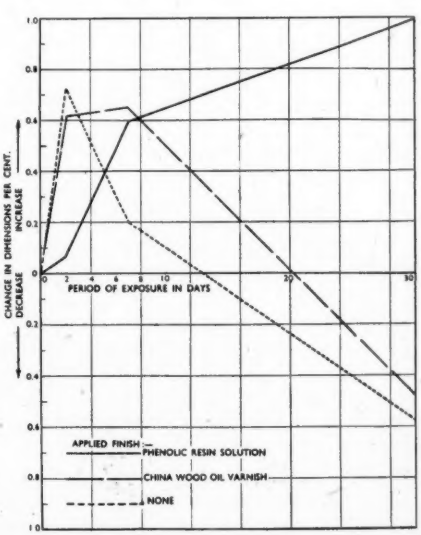


Fig. 3 (left).—Shrinkage in thickness, cellulose-acetate test pieces, with and without applied finish, exposed to dry heat at 60°C.

Fig. 4 (right).—Changes in length, cellulose-acetate test pieces, with and without applied finish, upon extended water immersion.



not, however, fully stable in the dimensional sense and tends to "breathe" with fluctuations in temperature and humidity in the atmospheres in which exposed. Where close dimensional tolerances are not imposed, and where components are very small, this may not matter, especially if the article is freely positioned, e.g., a loose-fitting window in a frame as contrasted with one rigidly fitted with fixing screws. This dimensional movement is probably a compound effect of two phenomena. First, the cellular structure of cellulose acetate causes it to be absorptive to a small degree, so that the material responds to humidity, gaining with an increase and losing with a decrease in moisture content of the surrounding atmosphere, or similarly showing a gain or loss in weight with fall or rise in the ambient temperature. These losses or gains, accompanied by corresponding weight changes, must result in proportionate volume changes. The latter, of course, are not necessarily equally distributed in the three dimensions of length, width and thickness. They may occur in an apparently quite illogical manner, but probably according to the distribution of stresses in the material. These stresses can be induced during manufacture of the material, as in rolling, extruding, pressing or moulding. They may be added to by the manner in which the component is assembled. Secondly, cellulose acetate, whether sheet, rod, tube, film or moulding, is generally plasticized with a material that, relative to the acetate base itself, is volatile. There is always a tendency for this to "dry out," a tendency that increases with temperature rise. This results in a tendency to shrink gradually till equilibrium is attained. The compound effect experienced in practice is that of fluctuating dimensions with a tendency towards more shrinkage than expansion. Also, it is observed that, when complete or intermittent water immersion is entailed, some grades of acetate exhibit a very marked loss in weight and dimensions, due, presumably, to seeping-out of plasticizer. It is pointed out that grades of cellulose acetate, variously described as cured, aged or matured, in which an endeavour has been made by thermal processing to reduce these propensities towards dimensional change to a minimum, are procurable. These efforts are only partially successful and the resultant materials still show the defect to a very marked degree. This can readily be seen from test results on a $\frac{1}{8}$-in.-thick black cellulose-acetate sheet of this type, one employed for producing pressings using wooden formers. The tests comprised the recording of weight and dimensional changes on specimens exposed for prolonged periods to the following conditions:—

1. Dry heat at 60 degrees C. For this test the specimens were freely exposed in an electrically heated oven, properly lagged and thermostatically controlled.
2. Water immersion. The samples were completely immersed in distilled water at 20-25 degrees C.
3. Humidity test, hot day, cold night.

This employed a zinc-lined teak cabinet closed by means of a closely fitting lid, which, in effect, comprised a wooden frame with glass panel. In the base of the cabinet trays of water were positioned. Temperature within the cabinet could be controlled by means of electrical heaters with variable resistances outside the cabinet. Specimens were exposed in the upper half of the cabinet. Uniformity of atmosphere was achieved by means of a slow-moving fan. Temperature conditions were 55 to 60 degrees C. during the day, cooling off to atmospheric at night. Corresponding humidity conditions were 70 per cent. relative humidity during the day, rising to 100 per cent. condensation during the night.

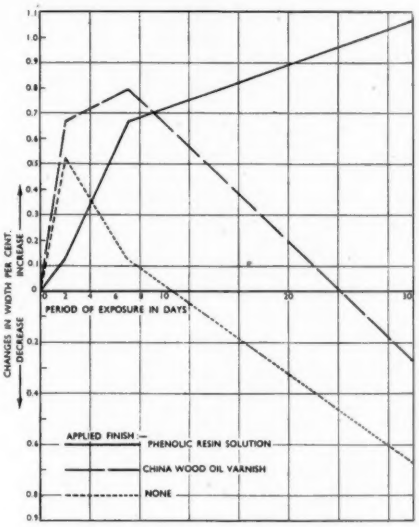


Fig. 5 (left).—Changes in width, cellulose-acetate test pieces, with and without applied finish, upon extended water immersion.

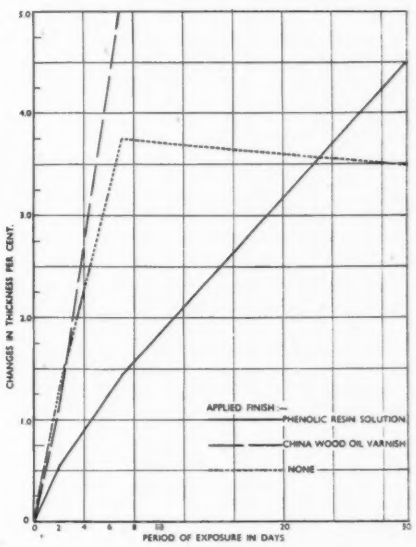


Fig. 6 (right).—Changes in thickness, cellulose-acetate test pieces, with and without applied finish, upon extended water immersion.

The humidity test, it will be noted, combined the effects of the dry-heat and water-immersion tests, but to a less rigorous degree, more nearly to that obtaining in average practice. The results of this exposure are of particular interest. Details are given below, the values quoted being percentages of the initial weights or dimensions respectively:—

1. Effect of Dry Heat at 60 degrees C.

Loss in weight during exposure period of:—

1 day ... 1.5 per cent.
10 days ... 3.2 per cent.
28 days ... 4.6 per cent.

Decrease in dimensions, per cent.:—

Exposure Period.	Width.	Length.	Thickness.
1 day	0.3	0.3	Nil
10 days	1.0	1.0	0.7
28 days	1.4	1.5	1.3

Table 1.—Dimensional Changes in Cellulose-acetate Test Pieces when Exposed to Dry Heat at 60°C. for Extended Period.
Size of Specimens approx. 6" × 1½" × ⅛". With and Without Finish.

Sample No.	Applied Finish	Period of Exposure	Dimensional Shrinkage					
			Length		Width		Thickness	
			Actual, ins.	%	Actual, ins.	%	Actual, ins.	%
1	None	2 days	0.047	0.78	0.012	0.80	0.0005	0.42
		7 days	0.070	1.17	0.016	1.07	0.0008	0.67
		30 days	0.112	1.87	0.027	1.80	0.0016	1.33
2	China wood oil varnish, two coats	2 days	0.038	0.63	0.008	0.53	0.0004	0.33
		7 days	0.061	1.02	0.014	0.93	0.0004	0.33
		30 days	0.093	1.56	0.023	1.53	0.0012	1.00
3	Special synthetic phenolic-resin solution, two coats	2 days	0.010	0.17	0.005	0.33	0.0004	0.32
		7 days	0.019	0.32	0.007	0.47	0.0004	0.32
		30 days	0.019	0.32	0.007	0.47	0.0005	0.40

2. Influence of Water Immersion

Increase in weight during immersion period of:—

1 day ... 1.1 per cent.
10 days ... 3.0 per cent.
28 days ... 2.2 per cent.

Increase in dimensions, per cent.:—

Period.	Width.	Length.	Thickness.
1 day	0.2	0.4	0.6
10 days	1.0	1.2	1.5
28 days	0.9	0.8	1.7

3. Exposure to Humidity—Hot Day, Cold Night

Change in weight:—

1 day ... 0.4 per cent. increase
10 days ... 0.5 per cent. increase
28 days ... 1.0 per cent. decrease

Change in dimensions, per cent.:—

Period.	Width.	Length.	Thickness.
1 day	+0.3	+0.4	−0.3
10 days	+0.2	+0.1	+0.4
28 days	−0.6	−0.8	+1.7

Briefly, the following conclusions can be arrived at from these data.

Dry heat causes loss in weight and decrease in all dimensions, the rate of change decreasing with increasing period of exposure.

Water immersion causes at first an increase in weight, followed by a decrease. Correspondingly, dimensions generally increase at first and then show a decrease.

The influence of humidity exposure upon weight is shown by an increase in the initial periods and a decrease in the final period. Dimensional changes are relatively smaller in length and width than in the other tests and are first expansion and finally contraction. The reverse effect upon thickness is peculiar, viz., initial shrinkage and final swelling.

The softening point of this sheet material was normal, viz., commencing at 80 degrees C.

This class of material is quite extensively used for pressing simple forms, such as those of box or shell type, not necessarily symmetrical. In order to confirm that the test data obtained upon sheet specimens were applicable to the pressed components, tests were extended to one of the latter. This comprised an unsymmetrical shell of elliptical section about its major axis and circular about its minor axis; the lengths of these axes were of the order of 25 ins. and 10 ins. respectively. The article comprised two halves, the split being along the major plane, and fixing by screws at close intervals in a flange along the junction. The latter was sealed with waterproof adhesive. Submission to the dry heat test at 60 degrees C. continuously for 10 days, resulted in 1 per cent. shrinkage on the major axis and 2.5 per cent. on the minor axis. On the humidity test exposure for 10 days the axial movements were immeasurable. Thus both these tests confirm the other results, but it should be noted that the component was suspended. When laid on a shelf in the test apparatus, collapse of the component to the extent of 6 per cent. occurred, due to its own weight and increased plasticity at the test temperature.

Table 3.—Comments on Visual Appearance of Test Specimens After Dry Heat and Water Immersion Tests, Detailed in Tables 1 and 2.

Test	Specimen No.	Applied Finish	Appearance After Test
Dry heat at 60°C.	1	None	Appreciable warping
	2	China wood oil varnish	Slight warping
	3	Phenolic-resin solution	Unchanged
Water immersion at 20/25°C.	1	None	Warped
	2	China wood oil varnish	Varnish became opaque white in one week and lost adhesion. In 30 days, varnish peeling off or blistered; thickness measurements could not be made. Warped
	3	Phenolic-resin solution	Slight whitening of coating in two days, but thereafter no change No warping and coating remained hard

Table 4.—Laboratory Characteristics of China Wood Oil Varnish.

CHEMICAL:	
Total solids (gum-oil base)	36.4 %
Volatile spirit	63.6 %
	100.0 %
Ash on incineration	0.90 %
Acid value (mgms. KOH/grm. of gum-oil base)	20.3
PHYSICAL:	
Specific gravity at 25°C.	0.877
Viscosity centipoises at 15°C.	177
Viscosity centipoises at 25°C.	112
Drying time (surface)	2¾ hours
Drying time (hard)	4 hours

Table 2.—Dimensional Changes in Cellulose-acetate Test Pieces when Immersed in Distilled Water at 20/25°C. for Extended Period.
Size of Specimens approx. 6" × 1½" × ⅛". With and Without Finish.

Sample No.	Applied Finish	Period of Exposure	Dimensional Changes					
			Length		Width		Thickness	
			Actual, ins.	%	Actual, ins.	%	Actual, ins.	%
	None	2 days	+ 0.043	+ 0.72	+ 0.008	+ 0.53	+ 0.0016	+ 1.33
		7 days	+ 0.012	+ 0.20	+ 0.002	+ 0.13	+ 0.0045	+ 3.75
		30 days	− 0.034	− 0.57	− 0.010	− 0.67	+ 0.0042	+ 3.50
2	China wood oil varnish, two coats	2 days	+ 0.037	+ 0.62	+ 0.010	+ 0.67	+ 0.0015	+ 1.20
		7 days	+ 0.039	+ 0.65	+ 0.012	+ 0.80	+ 0.0068	+ 5.44
		30 days	− 0.028	− 0.47	− 0.004	− 0.27	—	—
3	Special synthetic phenolic-resin solution, two coats	2 days	− 0.004	+ 0.07	+ 0.002	+ 0.13	+ 0.0007	+ 0.56
		7 days	+ 0.036	+ 0.60	+ 0.010	+ 0.67	+ 0.0018	+ 1.44
		30 days	+ 0.060	+ 1.00	+ 0.016	+ 1.07	+ 0.0056	+ 4.48

Despite the shortcomings discussed—as already pointed out, these are not always of consequence—there is still the desire to use cellulose-acetate sheet for pressings, because of fabrication convenience, good mechanical strength, especially for impact or shock, general stability and, often, good electrical properties. In consequence, a search has been made for suitable applied finishes, whereby to improve dimensional stability. The obvious weak points to these procedures are that, first, the finish itself will possess only a limited life; secondly, it will tend to have only a delaying action upon the influence of moisture; and thirdly, its assistance in mitigating the influence of heat is doubtful. However, tests made upon a synthetic lacquer having a phenolic-resin base have given extraordinarily good results, and they are described in the following.

Conditions of Test and Explanation of Results

For the investigation an ordinary grade of $\frac{1}{8}$-in. black cellulose-acetate sheet was employed, using test specimens approximately 6 ins. by $1\frac{1}{2}$ ins. by $\frac{1}{8}$ in. Exposure tests comprised the dry heat conditions at 60 degrees C. and water immersion, with careful dimensional checks at intervals. Specimens having no applied finish were compared with those having two coats of the special phenolic-resin solution, and also with specimens having two coats of an air-drying china wood oil varnish, this being one of electrical insulating quality and having excellent characteristics of resistance to moisture penetration.

The test dimensional results are shown in detail in Tables Nos. 1 and 2, while in Table No. 3 a concise summary of the resultant visual appearances of the specimens is given. For rapid appreciation, the dimensional change values are illustrated graphically for the heat test in Figs. Nos. 1, 2 and 3 respectively for length, width and thickness, and similarly for the water immersion test in Figs. Nos. 4, 5 and 6. On the heat test the special phenolic resin shows outstanding merit; only small shrinkage occurs, and stability is rapidly attained. The china wood oil varnish, on the other hand, shows little improvement over the unfinished specimen. These remarks apply to all three dimensions. Also, from Table No. 3 it will be seen that the synthetic treatment appeared to prevent the warping that occurred in the other specimens.

On the water immersion test, Table No. 2 shows that the synthetic varnish itself withstood the conditions excellently, whereas the china wood oil varnish failed badly. The curves in Figs. Nos. 4, 5 and 6 show that the synthetic phenolic varnish prevented the dissolution of plasticizing ingredients from the acetate, and in this sense provides a protective coating that assists in the retention of initial properties of flexibility. They show, however, that this varnish solution does not prevent the ingress of moisture, but that it slows down the rate of absorption very appreciably; this fact is borne out by the initial portions of the respective curves, before the period at which loss of plasticizer in samples Nos. 1 and 2 exceeded the rate of gain of moisture content.

The characteristics of the china wood oil varnish employed are given in Table No. 4. It was applied by spray, with a day's drying between coats, and six days after the final coat for full maturing before test.

The special phenolic-resin solution employed was a proprietary one, recently developed to yield a tough, resilient film with high resistance to water, solvents and chemicals. The solution as supplied comprised three separate constituents, viz., lacquer, catalyst and thinner. They were mixed to maker's stipulation of 1 part of catalyst to 10 of lacquer, followed by 30 per cent. of thinner. The mixture is prepared as required. Two full coats were applied by spray, with 20 minutes' drying between coats. The finish was dry for handling in about two hours, and was then allowed six days at ordinary temperatures for polymerization and full hardening.

The china wood oil type of air-drying varnish is an established one employed extensively for the surface finishing of laminated Bakelite products, and in particular the cut edges of components blanked from this material, for moisture proofing for electrical purposes. It is also widely utilized for wound coil treatments, for sealing and impregnating, in order to provide moisture resistance and to satisfy tropical conditions. The same class of varnish is used for woodwork for exterior finishing, doors, boat and coach work, etc. This renders the performance of the special synthetic phenolic-resin varnish particularly noteworthy. At first sight it offers obvious practical objections, first, in the need to mix ingredients as required for application, secondly in the relatively slow drying time. These must be considered as "necessary evils" upon which the success of the finish is dependent. The catalyst is the ingredient that induces polymerization and hardening of the resin without the application of heat, and it is evident that it cannot be present in the liquid varnish until shortly before the latter is to be applied. The soundest phenolic varnishes have had to be stoved, and then generally have produced rather brittle films. For even sounder films by air-drying processes, the six-day hardening period can be tolerated in the present stage of development, particularly when it is borne in mind that the work can be handled after a few hours. Again, the hardening process can be accelerated by limited heat, e.g., two hours' air drying at atmospheric temperature, followed by 12 hours at 100 degrees F. (38 degrees C.).

Note.—The special synthetic referred to in this article is one of the P.H. glazes marketed by Messrs. Phenoglaze, Ltd., Croydon, Surrey.

Improvements in Resin-bonded Diamond Grinding Wheels

The principal difficulties in the development of resin-bound diamond wheels were the relatively rapid loosening of the expensive abrasive particles from the bond (especially when the wheels are used wet) and the long time required for moulding and baking the wheels. A marked improvement in the water resistance of phenol-resin bonds has been obtained, according to U.S.A. patent No. 2,213,332 (A. L. Ball, assigned to the Carborundum Co., Niagara Falls), by adding alkaline oxides or hydroxides to the moulding powders. These chemicals also accelerate the thermo-setting process and modify the bonding properties. The abrasive grains are, for instance, completely wetted in a sodium silicate solution, when mixed with the phenol resin and suitable binders, followed by the standard treatment between hot platens, but with reduced time. The composition in one instance was 20 per cent. abrasive particles, 1 per cent. sodium silicate (precoat on particles), 25 per cent. powdered synthetic resin, 2.5 per cent. powdered lime, 51.5 per cent. filler (quartz 200 mesh and finer). The time required could be reduced in the case of this material from 16 hours to 1 hour, with a curing temperature of 350 degrees F. and a pressure of 2,000 lb./sq. in. An indication of the improvement in water resistance can be gathered from the fact that after three months' immersion in boiling water the new product showed a tensile strength of 1,500 to 1,800 lb./sq. in., compared with only 200 to 300 lb./sq. in. of the usual product after a few days' immersion in boiling water.

World's Industry

GENERAL ENGINEERING

Requirements of bearings in synthetic plastics investigated prior to war by Archangelski and Poddvjvev showed that the use of phenol - formaldehyde resins with cotton fillers gave reduced coefficients of friction for all speeds. Graphite additions proved of benefit. The use of the cotton in the form of woven material gave superior results to the use of the unwoven yarn. **Form and production of dies** for moulding is considered by Sprenger in a past issue of "Maschinen-Bau; Der Betrieb." Particular attention is drawn to the locating of parting lines, and hence the positioning of the flash, and to the provision of adequate contraction facilities. The author considers gas heating of moulds to be uneconomical and suggests the widest possible use of resistance heating, induction heating being recommended for massive moulds. **Hardness determinations,** even on metals, may be complicated by time effects, which for plastics assume a vital rule. Frölich, in an account in "Kunststoffe," describes an adaptation of Herbert's "rolling ball" method, by means of which many of the difficulties formerly experienced may successfully be overcome. The importance of the time factor in the case of plastics is due to the tendency of the materials to flow. With a 5 mm. ball, a 2 kg. load and a 10 secs. period, roll-hardness figures were obtained as follow:—Astralon, 3,751; cellulose acetate, 705; celluloid, 1,238; Plexiglas M222, 3,821; Plexiglas M132, 2,912; Trolit, F4,658; Polystyrol, 2,516. Comparison of roll-hardness values for different loading times (say 1, 10 and 60 secs.) enables some idea of plastic deformability to be obtained. Such data as these should prove of value in structural engineering as well as to the mechanic. **Heat conductivity and specific heat** for plastics may be measured simultaneously in the Bunsen steam calorimeter, results being obtainable in 10 mins. Accuracy is of a sufficient order for all technical purposes. Gottwald, at the Institute of Technical Physics, Darmstadt, elaborated a simple method, which is described in a past issue of "Kunststoffe." The author presents a discussion on both the theory and practice of his method. **Construction and assembly work** in general engineering is concerned largely with the manipulation of various semi-finished forms. Raalf, writing in "Kunststoffe," discusses at some length problems relating to the working up of thermo-softening resins. Moulding, shaping of sheet and foil, jointing of plastic parts, and the working of tubes and sections are considered. Of particular interest are notes on the working of the very soft plastics contained in this account ("Kunststoffe," Vol. 29, No. 10). The hardness envisaged covers that between soft rubber and leather. For many purposes the normal working techniques may be used, but for plastic forming, the highest possible temperatures are advised, in order to avoid elastic recovery from arranged form. Handling technique is contrasted with that usually employed for different types of rubber. **Rationale of designs of moulded components** is dealt with at length in a special V.D.I. publication. The subject matter has again acquired topical interest, in that the points raised recur constantly when need arises for one material to be used in place of another. The tendency to use an established or traditional design irrespective of the material in which the work is executed, has led to failure or, at the least, only partial success, in light alloys and plastics. Designs should be examined carefully in the light of the mechanical and physical properties of the material. It is interesting to note that many of the precautions suggested, such as adequate "radiusing" and ribbing, reasonable uniformity of section or absence of abrupt transition from thick to thin sections, are in alignment with those desirable in cast light alloys. **Jigs, templates, collets and chucks** in hard paper or laminated plastics are discussed by Wirth in an article in "Kunststoffe." The author points out that these materials show a deflection strength of 8-12 tons/sq. in., being little inferior in this respect to cast iron and certainly superior to wood. Compressive strength lies between 12 and 20 tons/sq. in., a value much above wood and not markedly inferior to wrought-iron. Impact strength is less than that of mild steel but well above that for cast iron. At a time when so much is being talked of aluminium alloys, it is as well to point out that the specific gravity of these non-metallics is one-quarter that of aluminium and one-sixth that of steel. Their wear resistance is superior to that of many structural alloys. **Surface finish,** so long regarded as important for engineering purposes in metals, is of no less importance in plastics. Klingelhoffer and Müller, of Darmstadt, published some short time ago the results of an exhaustive investigation of the measurement and significance of surface quality in plastics, bearings being specifically referred to. A special back-reflection method was devised, ordinary and polarized light and monochromatic light sources being used. The theory and practice of the testing methods employed are critically considered.

ELECTRICAL

Novel method of determining water-absorbing capacity of massive plastics is described by Déribéré and noted by Buccard in the journal "Rev. Gen. Matières Plast." One side of the part to be tested is dusted with rhodamine or some other suitable fluorescent agent. The other side of the part is now allowed to come into contact with water, either at normal or elevated pressures (and, with suitable precautions, we would suggest at room and elevated temperatures). The dusted surface is illuminated with a U.V. lamp and the time taken for fluorescence to commence forms a comparative basis for recording water absorption capacity. It is suggested that this test ought to be of value more especially in routine laboratory checking of parts for electrical apparatus. **Russian standardization of test methods** for plastics designed for use in the electrical industries includes the codification of resistance-testing technique. Transverse and surface resistance are measured at 65 and 100 per cent. relative humidity. Resistance measurements are carried out on a specially designed apparatus incorporating a condenser device by means of which "creep" currents of low magnitude may be detected.

BUILDING

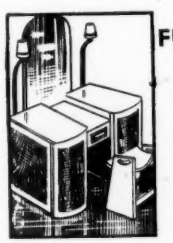
Comparison between silicate glasses and organic glasses is drawn by Troninsdorff in a past account devoted principally to the lighter decorative uses of Plexiglas. Argument centres on the great ease of producing "ground" and "cut" decorative effects on the latter as compared with the slow and sometimes hazardous task of wet-grinding the former, more especially when compound glass sheets are being used for colour effects. For organic glass, high-speed hand milling cutters

ry Employs Plastics

or small rotary files of the type used for working light alloys are employed. No flooding with water is required and an unlimited range of effects is possible by the use of masses built up of numerous superimposed colours.

CHEMICAL

Apparatus employed in tanning is exposed to powerful corrosive influences. For this reason, copper is largely employed in its construction. A recent issue of "Collegium" details the results of an investigation into the possibility of substituting synthetics for metal in this connection, attention being devoted primarily to corrosion resistance, which was compared for phenol-formaldehyde resins, polyvinyl resins and laminated (fabric) plastics. The testing solutions included quebracho, various barks, cellulose extracts and synthetic tanning agents, these being used at room temperature and at 50 degrees C. for periods varying from one to twenty weeks. Corrosion was determined by loss in weight of a plate 50 by 10 by 1 mm. For Igelit PCU, Mipolam, Neoresit and Haveg, no corrosion was visible even after 20 weeks' exposure to vegetable solutions, nor was weight-loss significant. For Novotext, Dureaton and Turbax, weight-loss was appreciable and increased in the order given. Synthetic tanning media attacked more vigorously, the polyvinyls and phenolics showing the best resistance. The plastics also resisted acid solutions well. In contrast to metals, corrosion resulted in no *visible* decomposition products.



FURNITURE

Barrel polishing of moulded components, employing as an abrasive only sawdust (pine sawdust free of tar and pitch) is a highly economical method for finishing small decorative items of cabinet-maker's and carpenter's furniture. For rougher purposes coarser abrasives may be mixed with the sawdust. The barrel used should always be made of wood, again a non-greasy, resin-free timber being selected for the purpose. As opposed to wheel-buffing, barrelling offers little chance of local overheating and smearing or discoloration of the most sensitive plastic surface, and would, therefore, strongly commend itself for the organic glasses.

TEXTILES

Production of a successful casein fibre by Ferretti in 1924 and the opening of a works in Germany for the manufacture of Tiolan (the German equivalent of lanitol) are described at length in "Zellwolle." Much space is devoted to convincing argument as to the similarity in chemical, physical and mechanical properties between natural wool and Tiolan. Spinning and dyeing techniques are the same for wool and Tiolan, which, however, is more sensitive to heat, acids and alkalis than the natural product. It is pointed out that Tiolan does not show the hollow coring characteristic of natural wool.

MISCELLANEOUS

Metallurgical significance of characteristic types of fracture surface is well known. Recently Rexer ("Z. techn. Phys.") investigated plastic fractures to determine the extent to which such surfaces for organic glasses resembled those for inorganic glasses. Tensile tests were carried out on Polystyrol and on Plexiglas, which were shown to give a fracture partly smooth and partly coarse in character, the precise form of which depended largely on conditions of tests and on the pretreatment of the test pieces; in these latter respects the organic glasses differ from the inorganic glasses. Different resins were shown to give, under any predetermined testing conditions, characteristically different fractures, a feature which might be turned to advantage for identification purposes. **Oxamide and paraformaldehyde** as addition agents to inhibit the darkening of phenolic resins in the C. stage formed the subject of a study by Lück presented in "Kunststoffe." These substances, besides accelerating curing, have a notable effect in preventing undue darkening of the resin. Dioxan was also shown to have similar effects and to act as a powerful accelerator. **Light-transmitting qualities of packings** are often of importance. Deichmüller, writing in "Kunststoffe," presents a discursive review on practical means for rendering plastic packings impermeable to various radiations; in particular, to ultra-violet light. It is pointed out that many of the problems encountered are dealt with in the patent literature, which is briefly surveyed, reference being made especially to the use of photodynamic additions to the packing materials. The nature of applied films of adsorptive agents is then considered in relationship to particular groups of plastics, the technique of their application is discussed, and the possible negative effects of certain apparently protective colourings noted. **Die steels for moulds** were examined in a paper by Briefs read before a meeting of the plastics section of the V.D.I. Casehardening sticks containing from 0.1 to 0.2 per cent. carbon, with or without nickel addition from 3.5 to 4.5 per cent., and chromium from 0.7 to 1.2 per cent., together with manganese from 0.5 to 1.5, comprise one range examined. One of this group contains 0.3 per cent. tungsten. Air- and oil-hardening steels are also listed, with carbon contents from 0.35 to 0.45, nickel 1.5 to 4.5, chromium 0.8 to 2.5, manganese 0.5 to 1.0, with certain members of the group containing tungsten 0.5 per cent., or vanadium 0.2 per cent., and molybdenum 0.2 to 0.7 per cent. The alloy tool steels discussed have carbon contents from 0.9 to 2.0 per cent., with chromium from 0.6 to 13.0 per cent., tungsten 1.0 per cent., vanadium 0.2 to 0.7 per cent., in one case molybdenum 1.0 per cent., and manganese 0.3 to 1.8 per cent. Mould steels for chemically active resins contain 13 per cent. chromium, with carbon from 0.3 to 1.3 per cent. Steels ready for immediate use on delivery are recommended where possibilities for heat treatment are lacking; compositions cited are carbon 0.5 to 0.65, manganese 0.5 to 1.5, chromium 0.5 to 2.0, nickel 1.5; two of this group contain additions of molybdenum from 0.2 to 0.3 per cent. **Comprehensive account of the testing equipment** for plastics in the Staatlichen Materialprüfungsamt (Berlin-Dahlem) is provided by Nitsche in a description in "Kunststoff-T.u.K. Anwendung" (Vol. 9). Special apparatus has been developed for determining U.T.S., impact strength, endurance strength, bearing properties, dimensional stability, internal stresses, thermal expansivity and conductivity, fire-resisting properties, and chemical and physical properties of every type. The account, which covers eight pages, illustrates the construction and operation of much of the apparatus, and describes sampling technique.

Inquiries and Answers

(In Which is Included General Correspondence)

IMPORTANT NOTICE: If inquirers wish to receive replies by post, a stamped and addressed envelope must be included in their letter. It is understood that the submission of a problem to the Editor permits its publication in this journal.

Tannery Buckets of Plastics

We should be very glad if you could tell us the names of any firms who are making laminated plastic buckets, as we think they may be useful to us in the tannery and dye house.

W. AND A. J. TURNER (IPSWICH), LTD.

Ipswich.

[EDITOR'S NOTE.—We did not know that anybody was making buckets of laminated material. We suggest the inquirers ask the opinion of concerns such as J. Burns and Co., Ltd., who could probably fabricate buckets from a new resin impregnated fabric they are developing, I.C.I. (Plastics), Ltd., who might suggest a synthetic rubber, or concerns like North British Rubber Co., Ltd., or Charles Mackintosh, who make rubber buckets for the chemical industries. The inquirers do not say if their use entails acid or alkali or both.]

Distinguishing Between Acetate and Polyvinyl Resins

We are desirous of being able to distinguish between the materials used for making electrical wire covering as supplied to us, that is, between cellulose acetate and polyvinyl chloride, by a simple method. We have not a chemical laboratory attached to the works. C.

London.

[EDITOR'S NOTE.—A good method is to send the samples to a consulting chemist—a member of a very deserving section of the community. However, a rapid method of distinguishing between the two plastics mentioned is to test for chlorine. Heat a copper wire in the flame of a gas burner until the green colour disappears. Withdraw the wire and while still hot touch the plastic and replace in the flame. If the flame turns green the plastic contains chlorine. Care must be taken in translating this simple test, for chlorine may be present in a plastic of whose real constituents the buyer knows little. Thus, for example, a softening agent such as chlorinated diphenyl may be included in a plastic. Or a chlorinated solvent may have been used in its manufacture—cellulose acetate films have been made from acetate lacquers containing tetrachlorethane, and even chlorbenzene has been used as a solvent for resins and rubber-like compounds, such as polyvinyl chloride. Thus, the copper wire test is far from being conclusive. However, if the inquirer knows that the two plastics are cellulose acetate and polyvinyl chloride, and if one of them does not give the green flame, he can be certain that it is the acetate. The polyvinyl chloride is bound to give the green colour.]

Cold-setting Cement

In the October issue of "Plastics" there is an editorial paragraph headed "A Cold-setting Cement." On reading this one might form two wrong impressions:—

(1) That urea-formaldehyde glues do not set in the cold.

(2) That the particular synthetic cement to which you refer is the first cold-setting synthetic cement which has been available to the plywood trade.

The facts are that the cold-setting properties of urea-formaldehyde glues have long been recognized and utilized, so contributing largely to their success. The hot pressing of urea bonded plywood is employed because of the increased production per press available by this method.

We enclose herewith a booklet, "Synthetic Cements for Wood," issued by our subsidiary company, The Beetle Products Co., Ltd., and on pages 22-26 details are given of the applications of Beetle cements for cold-setting.

We feel that an inaccurate impression might be created by your article, which, in the circumstances, you may wish to amplify.

BRITISH INDUSTRIAL PLASTICS, LTD.

London, W.1.

Production of Metal Powders

In the October issue of "Plastics" there is a note that, as far as you are aware, stamps for producing flake metal powders are not manufactured in this country. I suggest you get in touch with Mr. Bernard Barbour, of Bentley and Jackson, Ltd., Lodge Bank Works, Bury. This firm has, to my knowledge, made a number of machines for this purpose since the outbreak of war.

Hayes. H. ERIC SCOTT.

Electric Screens on Plastics

Referring to your pages "World's Industry Employs Plastics" in the October issue of your journal, under Electrical Section you mention "electrical screens on a plastic base offer great promise for both present and post-war use." We are in a position to manufacture such screens, and can spray most types of metal on to certain cast resins. This method of fabricating has been developed to a high degree of accuracy for all types of uses in engineering.

With regard to your other article on page 195, "Seeing How it Works," we are shortly placing on the market a transparent lubricating system using Catalin crystal clear material for certain parts; this is carrying "Seeing How it Works" into engineering practice. We shall also be placing fuel systems on the market on similar lines.

Most serious stoppages occur in all types of machinery and prime movers because of lubrication breakdown, and generally the whole system has to be taken down to ascertain the cause of stoppage. This need occur no longer, as the oil or fuel will be in full view all the time and considerable sums can be saved on maintenance. Of course, patents have been applied for in all instances.

If you know of any parties interested in electrical screens or cabinets, or lubrication and fuel systems, we would appreciate it very much if our name were placed before them.

Thanking you for a most interesting journal—with ideas. V. N. SCOTT.

London, W.5. Independent Plastics.

PRODUCTION NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes

AUTOMATIC INDICATION OF TEMPERATURE RISE.—For many conditions it is valuable to have some device that will indicate automatically, say, by a bell or hooter, when temperature reaches danger point, and in this connection of considerable interest is the new "Rototherm Rotostat," operating on the bi-metal helical-coil principle. The arrangement consists of a small and compact all-metal casing, with a screw top and a stem of desired length, inserted in the bearing or other equipment at the point. Several standard temperature ranges are available, and by means of an adjustable setting plate the instrument is set to give a warning at any desired temperature. When the latter is reached an electrical contact is made, and according to one arrangement a three-terminal bell is used, so that when the contact is made the instrument itself cuts out and the current is left full on the bell, which goes on ringing until reset by a push-button, cord, or similar device. For operating a large bell or hooter a relay is necessary so as to bring into action a more powerful current.

The instrument is a production of the British Rototherm Co. Ltd., of London, and operates on the same principle as the firm's range of dial thermometers. In the stem at the bottom is a small, compact, multiple-helical coil, consisting of a thin and very narrow strip formed of bi-metal, that is two alloys of greatly differing properties as regards expansion and contraction, made by pressing together the original billets when in the heated condition. A bi-metal coil expands or contracts in pronounced fashion with great accuracy in direct proportion to the temperature.

B.S.S. COMBINED DRILLS AND COUNTERSINKS.—At the request of the Ministry of Supply, the British Standards Institution has prepared and is about to issue a War Emergency British Standard relating to the dimensions of combined drills and countersinks (B.S. 985-1941). The principal object underlying the preparation of this specification has been to bring about a simplification in the variety of sizes and types of combined drills and countersinks at present manufactured and so to facilitate more rapid and economic production by concentrating the supply and demand upon a simplified range of seven sizes with one standard angle of countersink. In general, the specification represents a selection of the most suitable sizes of drills from those at present manufactured. Some slight changes from existing practice have, however, been made in the case of the body diameters of three of the drills scheduled in order to permit of the whole range of drills being manufactured from those sizes of ground bar likely to be most readily available during the periods of the war.

Copies of this specification, etc. (No. 985-1941), may be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1, price 1s. 3d. post free.

ENGINEERING BULLETIN of November, 1941, the publication issued by the Ministry of Labour and National Service, contains a very important article under the title of "Training Mouldmakers for the Plastics Industry." At a time when skilled workmen in our tool industry are at a premium, the new schools that have been organized to give new-comers high-grade instruction is of deep significance. Excellent photographs show some of the fine precision mouldings made by new workers after a comparatively short but intensive period at the training centres. This booklet should be read by all tool-makers.

Trade Notes

The Minister of Supply has made the Control of Plastics (No. 2) Order, 1941, under which the provisions of the Control of Plastics (No. 1) Order, 1940, controlling acquisition, disposal, treatment, use and consumption of certain plastics, are extended to cover synthetic resins in the production of which formaldehyde, cresol, phenol, urea or thiorea has been used.

Application for licences under the Order, which comes into force on November 17, should be addressed to the Ministry of Supply, Plastics Control, Great Burgh, Epsom, Surrey.

Copies of the Order may be obtained from H.M. Stationery Office, York House, Kingsway, W.C.2.

The Board of Trade has announced that whereas the existing quotas for pottery and some other articles of household use are to be further reduced, the plain undecorated type of crockery will be entirely freed from restrictions for six months from December 1. Moreover, the quota for cups and saucers, plates and tumblers of plastics will be raised from 25 to 50 per cent.

Erinoid, Ltd.—The trading profit of Erinoid, Ltd., the well-known manufacturers of casein products, synthetic resins, etc., to July 31 increased by £25,400 to £76,884, compared with the previous year.

SALVAGE OF WASTE PAPER.—The Government war on the wastage of paper is without doubt one of the major economies in which we can all help. Vast quantities of paper are hoarded or destroyed, and this waste, if not checked, will seriously impede the war effort. Paper has been cheap and very large quantities of raw material have come into this country every year. Now, because important sources of supply are in enemy hands, there is not the quantity available even for necessary use.

If, however, 75 per cent. of the paper used could be reclaimed, one of the most vital aspects of the munition problem would be solved. It is urgent that everybody should examine what waste paper there is in household, in office, or in factory, and should see to the means of collection through the local council. Where quantities of one ton or more of waste paper are available, as might happen when clearing out collections of account books and office files, then it would be possible to dispose of it to an approved waste-paper merchant.

One of the essentials in collection is that each householder should separate the paper, cardboard, etc., from all other refuse, keep it clean and, above all, from grease. Greasy paper is best used for lighting fires. Every class of waste is wanted, such as old periodicals, books bound and unbound, picture postcards, Christmas cards, price lists, catalogues, time tables, wall paper, paper wrappings, cartons—anything of a paper origin. It should be bundled for easy collection. Waste paper can be made into good paper and re-used for hundreds of articles of the greatest importance in our war effort.

Furthermore, we ask readers to bring to our notice any cases of waste of paper, or any difficulty, such as through the local council failing to make effective collection. We cannot answer correspondence on this subject, but all reports will be brought promptly to the notice of the Minister of Supply.

Resinoids and Other Plastics as Film Formers

By B. J. BRAJNIKOFF, Consulting Electrical Engineer

One-time Consulting Engineer to the International General Electric Co., Inc., New York

II.—Plastics Synthesis in Relation to Raw Material Base (contd.)

Acetylene as a Chemical Base

THE utilization of gaseous hydrocarbons resulting from petroleum cracking, especially of olefines, is the characteristic feature of the trends of organic synthesis in the U.S.A. In Canada and in Germany, where petroleum deposits are small, the same industry is based mainly on acetylene.

The possibility of building up an analogous industry of the organic synthesis, either upon olefine hydrocarbons from cracking gases from natural and technical sources or upon acetylene, is perhaps the most important feature of modern organic plastics manufacture, as may be clearly seen from the examples.

Vinylacetates may be obtained from ethylene by the action of a halogen and of sodium acetate (the method of the U.S.A.), or from acetylene by the action of acetic acid in the presence of mercury catalysts (the method used in Canada and Germany).

Vinylchloride may also be produced from ethylene by the action of potassium hydroxide on its dihaloid derivatives, or from acetylene.

Acetic anhydride can be obtained through acetic acid synthesized either from acetylene or through ketene derived from pyrolysis of acetone.

Butadiene can be derived either by the pyrolysis of ethyl alcohol (method of U.S.S.R.) or by the catalytic dehydrogenation of butylenes and butane (U.S.A.), or through 1.3–butyleneglycol, synthesized from acetylene (Germany).

Of course, the first pre-requisite for utilizing the acetylene as a raw material must be the possession of cheap electric power, just as the use of olefines, on the other hand, demands a large cracking industry.

At this point mention should be made that one of the largest branches of the modern organic synthesis in the U.S.A. is the manufacture of synthetic products employed as components for the preparation of motor fuels, such as iso-octane and recently 2.2.3–trimethylbutane, obtained from cracked gases. In admixture with tetraethyl-lead the above products greatly improve the antidetonation properties of liquid fuels expressed in octane numbers; high octane fuels efficiently solve the problems of speed and distance flying. In 1922 the octane number of an average trade specimen of gasoline was 43; by 1940 the military aviation adopted fuels with octane numbers 116-125.

As a consequence of the structural changes in motor fuels, the branch of petroleum industry that is concerned with the conversion of oil into high-grade petrol has claimed if not all, at any rate, a major share of the cracked gases and a high proportion of natural gases (except methane). This trend must inevitably lead to the prominence of acetylene as a raw material for organic synthesis even in the U.S.A.

Until recently acetylene has been produced in the U.S.A. entirely from carbide of calcium, with an annual output of about 75,000 tons, and this was used chiefly for the synthesis of acetic acid. At present, special efforts are being made to develop other methods for obtaining acetylene at lower cost.

The situation as outlined above has given rise to interest in two problems: (1) the conversion of industrial and natural gases into olefines, (2) the transformation of these gases into acetylene.

The main supply for organic synthesis in the U.S.A. are the gases derived from cracking in the vapour phase, in particular gases from installations of the Giro system, which yields 20 per cent. of gas with a general content of unsaturated hydrocarbons up to 40 per cent. and containing about 25 per cent. of ethylene. Unsaturated products as raw materials are also obtained by means of the pyrolysis of saturated hydrocarbons. Thus ethylene is produced by the pyrolysis of ethane at 800-850 degrees C. By modifying the composition of gas from the cracking in liquid phase as a result of its pyrolysis at 600-700 degrees C., the ethylene content can be increased from 3 to 18 per cent.

A new process has recently sprung into prominence in the U.S.A.—the catalytic dehydrogenation of saturated hydrocarbons into unsaturated products. This method, which is already finding its application in industry, is of prime importance not only in the production of ethylene, propylene and butylene from the corresponding saturated hydrocarbons, but also the diene compounds—butadiene and isoprene for synthetic rubber—from butane and pentane.

Moreover, the conversion of saturated hydrocarbons of natural or technical gases into olefines may be enhanced by the thermal decomposition (e.g., by electrocracking) of a rich methane fraction (often containing 95 per cent.), into hydrogen and acetylene.

American experience shows that acetylene obtained from this source is far more economical than that based on coal.

The Methane Problem

At this juncture it is worthy of note that the utilization of methane offers exceptional advantages to Great Britain, which, while lacking natural petroleum deposits, has abundance of this gas at her industrial works.

As has been ably demonstrated by Dr. J. P. Lawrie in his recent monograph on the subject,[6] the known sources of methane in the British Isles are at present substantial and their development will render them vast. In addition to replacing a considerable part of petrol now imported, the use of the actual and potential supplies of methane may provide a prolific source of many important chemicals for the plastics field and other

industries. For example, as has been proved by Egloff and Tropsch, pyrolysed methane at high temperature and reduced pressure (1,400 degrees C. 50 mm. Hg.) gives a high yield of acetylene (12 per cent.) and ethylene. The gases may be also made to give appreciable amounts of aromatic products.

Moreover, by means of halogenation methane gives good yields (75 to 90 per cent.) of many other compounds, viz., methyl chloride, carbon tetrachloride, methylene chloride, formaldehyde, etc.

By catalytic oxidation methane yields methyl alcohol and methanol. By nitration of methane a series of valuable raw materials are obtained, e.g., selective solvents for resinoids, etc.

In reviewing the nature and uses of methane gas, Dr. Lawrie emphasizes that, since no systematic estimation of supplies of the gas has ever been made at points of occurrence (i.e., collieries, coke ovens, sewage works, borings for oil in Scotland and other areas, where it is allowed to go to waste), no accurate figures of existing supply can be furnished, but it may safely be assumed that the volume of methane available yearly in this country is of the order of many hundreds of billions of cubic ft. (ignoring for the present such potential sources as coal, coal gas and water gas).

Ramifications of Ethylene

In addition to the production of ethyl and isopropyl alcohols, ethylene and propylene furnish a very fertile base for the manufacture of many other indispensable products, such as glycols, glycerine, glycol esters, ethanol amines and other compounds. The scope of syntheses on the ethylene basis is very great. Thus the preparation of synthetic ethyl alcohol, the most important product derived from ethylene, exceeded 100,000 tons in 1936 in the U.S.A., at a cost not higher than the same commodity obtained by fermentation. From ethylene and hydrochloric acid is derived the highly important ethyl chloride, chiefly used in the manufacture of the tetraethyl lead for up-grading motor fuels, and of ethylcellulose.

Besides this, ethyl chloride is used in synthesis of ethylbenzol—the raw material for the preparation of styrol. Derived from ethylene and chlorine, the ethylenedichloride is now utilized in synthesizing "Thiokol," acrylates, vinylchloride and vinylacetates.

It is worthy of note that acrylates may be obtained either from ethylene or from acetylene. Vinylacetates may be produced from ethylene by action of a halogen and then by sodium acetate, which forms an unsaturated ester of acetic acid (American method), or alternatively by the action of acetic acid on acetylene in the presence of mercury catalysts (method of Canada and Germany). Vinylchloride may also be prepared either from ethylene by the action of potassium hydroxide on its dihaloid derivative, or from acetylene, as a result of combining with hydrochloric acid. Acetic anhydride, indispensable in the manufacture of acetate silk, may be obtained either from acetic acid only or synthesized from acetylene, or by means of acetic acid and ketene, derived from propylene, i.e., with only half the expenditure of acetylene. Butadiene can be produced either by the catalytic cracking of ethyl alcohol (Russia) or through 1.3 – butyleneglycol, synthesized from acetylene (Germany), or again by means of the catalytic dehydrogenation of butylenes and butane (U.S.A.).

The glycol series include the following highly important products:—Ethylene glycol, propyleneglycol, diethyleneglycol), ethyl ester of ethyleneglycol (ethylcellosolve), methyl ester of ethyleneglycol (methylcellosolve), methyl ester of diethyleneglycol (methylcarbitol), methyl and butyl esters of diethyleneglycol, dioxane, dichlordiethylester (chlorex), ethylene oxide, cellosolve and carbitolacetates, ethylenedichloride, ethylene, and propylenechlorhydrins, propylene oxide, ethanolamines, ethylenediamine, acrylic acid and other compounds.

The manufacture of these products needs, besides chlorine, great amounts of acetic acid and methyl alcohol, which gave impetus for their large-scale synthesis in the U.S.A. on the basis of acetylene.

The synthesis of ethyleneglycol and series of its derivatives (from ethylene of cracking gases) necessitated a complete separation of ethylene from propylene. The success of the production of ethyleneglycol and its derivatives has led to utilizing propylene for obtaining isopropyl alcohol and acetone. The preparation of acetone at lower prices (as compared with acetone from forest sources or synthetic acetic acid) enabled the powerful Carbide and Carbon Chemical Corporation to organize the manufacture of ketene, and through the latter acetic anhydride and acetic acid.

Syntheses of Hydrocarbons of the Acetylene Series

The acetylene series has been studied much less than the hydrocarbons of the olefine and diolefine series. These hydrocarbons, because of their reactivity, are of a definite interest to the industry of plastics as film-formers, synthetic rubber, organic glass, etc.

Hydrocarbons of the acetylene series form a very convenient raw material base for the syntheses of the corresponding saturated aldehydes and ketones, ketals (dimethoxyalkanes), α – alkynile esters, dioxolanes and dioxolones (whose methods of synthesis have been worked out by Newland), alcohols of the acetylene series, acids and their anhydrides, amines, nitriles, etc.

Finally, quite recently Campbell and Connor have established that acetylene hydrocarbons could also be convenient raw materials for the synthesis of olefine and paraffin hydrocarbons. The latter may be readily obtained by means of the step-by-step hydrogenation of acetylene hydrocarbons over fused nickel catalyst.

Natural petroleum contains no hydrocarbons of the acetylene series, although mere traces may be found in products of the pyrogenetic decomposition of oil as conducted in usual conditions.

However, during a high temperature pyrolysis (at 1,000-1,400 degrees C., especially in electrocracking by means of the voltaic arc or under the action of electric discharges), both the liquid fractions of petroleum and methane are converted into acetylene. In addition, higher homologues of the acetylene may also be obtained through hydrocarbons of the olefine series, contained in the products of petroleum cracking.

The ability to enter into reactions with alcohols and saturated and unsaturated organic acids is possessed not only in acetylene itself, but its homologues as well. Simple esters of acetylene and its homologues, dialkoxialkanes, alkynyl esters, also form potential raw materials for various polymerization and condensation reactions, by means of which may be prepared diverse colourless plastics, extremely valuable film-forming substances with anti-corrosive properties, impregnants, technical cements and innumerable other products.

Acetylene as a Base for Plastics Synthesis

Acetylene is an excellent raw material for the production of not only chlorprene and divinyl rubbers, but also of isoprene, whose properties are more valuable than those of the divinyl derivative.

The largest producer of synthetic rubber from divinyl is Russia, where it forms the leading branch of industry of organic synthesis. The practical development of the Russian synthetic rubber has been the outcome of long researches by the distinguished chemists Kondakoff, Lebedeff, Ostromysslensky, Byzoff and others.

The manufacture of products of the aliphatic series in Russia is based principally on the raw materials of vegetable origin, the treatment of which is effected by the following methods:—(a) Biochemical (fermentation), (b) thermal decomposition of wood (sylvochemistry), and (c) chemical decomposition (hydrolysis of the cellulose, corncobs, etc.).

By means of fermentation of foodstuffs (wheat, potatoes, molasses) are obtained ethyl, butyl and amyl alcohols, acetone and other commodities. The hydrolysis of cellulose with the subsequent fermentation of the resulting sugars leads to the production of ethyl alcohol. From alcohol and acetic acid are derived the ethyl-, butyl-, and amylacetates employed as solvents for coating compositions, varnishes and paints.

Thus the manufacture of divinyl rubber in Russia, as practised by the original Lebedeff method, has so far been based on ethyl alcohol from exclusively agricultural sources, among which rye supplies approximately 60 per cent., potatoes 20 per cent., and molasses 10-15 per cent.

The cost of alcohol production from cereals is high. Each ton of the divinyl rubber requires 3.5-4 hectares of potatoes and about 12-15 hectares of corn. It has been estimated that the manufacture of synthetic alcohol from ethylene would give a product three to four times cheaper than alcohol obtained from foodstuffs.

Although in the output of ethyl alcohol Russia occupies the first place in the world, further progress of divinyl rubber manufacture there is greatly hampered by the fluctuation in supply of alcohol.

The above considerations have recently urged Russian scientists to pay greater attention to acetylene as a raw material, and to put already part of the synthetic rubber industry to the production of the chlorprene ("Sovprene") from vinylacetylene, as initiated recently at Erevan, in Transcaucasia.

The process of industrial synthesis of isoprene, as it has been introduced by the eminent Russian savant, Academician Favorsky, consists of the following operations:—

Acetone is condensed with acetylene into acetylene alcohol (dimethylacetylenylcarbinol). This alcohol is then subjected to electro-chemical hydrogenation, converting thereby the triple bond into double valency (methylbutanol into methylbutenol). Finally, the methylbutenol is dehydrated into isoprene.

Incidentally, it should be noted that the vinylacetylene (the intermediate product in the synthesis of chlorprene) as well as the divinylacetylene (a by-product in the chlorprene manufacture), owing to their high reactivity, may also serve as a prolific source for synthesizing diverse polymerization and condensation plastics.

The activities of the Institute of Organic Chemistry of the Russian Academy of Sciences are of special interest. As a result of focusing attention on the problem of the film-forming substances, great results have been achieved in widening the ranges of raw materials and the development of novel products. Particularly valuable results have been accomplished by the Favorsky school on film-formers of the vinyl ester class, synthetic rubber, anti-corrosive compositions and the like.

The vinyl derivatives include:—

I. Simple vinyl esters of a general formula, $CH_2 = CH.OR$, where R may be a vinyl, alkyl, aryl or alkylaryl radical.

II. Compound vinyl esters, produced by the interaction between acetylene and organic and certain inorganic acids.

III. Vinyl monohalogenides $CH_2 = CH.X$, of which vinylchloride is of the greatest practical importance. Simple vinyl esters are usually obtained, with good yield, from the interaction of alcohol (or phenols) with acetylene in the presence of alkali or other catalysts. On heating, in the presence of various catalysts, they readily polymerize into transparent, water-white, non-discolouring resinous products.

Compound vinyl esters are derived from the interaction of the acetylene with anhydrous carbonic acids, activated by mercury sulphate or mercury phosphate.

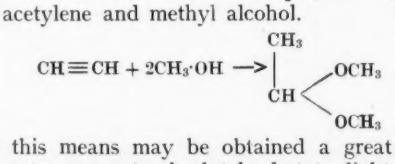
The polymerized esters (or polyvinyl esters) are colourless, crystal-clear substances, which are used for manufacture of valuable insoluble plastics—splinterless glass, rubber-like products, etc.

Polyvinyl esters may be condensed with unsaturated aldehydes (acrolein, croton aldehyde), with the formation of a soft vulcanizable mass.

Polyvinyl and vinyl esters can also be subjected to a simultaneous polymerization with saturated aldehydes (acetic, formic, etc.) and acrylates (esters of acrylic and methacrylic acids). The products of the polymerization of vinylchloride, sometimes in combination with cellulose esters, styrol, vinylacetate, are utilized as film-forming agents in varnish systems and other coatings.

The mixture, containing 65 per cent. of polyvinylchloride and 35 per cent. of a plasticizer (e.g., tricresylphosphate), results in a product which is characterized by the elasticity of rubber and anti-corrosive properties, and for this reason is used for coating chemical plant, etc.

Polyvinylchloride as well as polyvinyl complex esters, by means of the saponification, may be transformed into the so-called polyvinyl alcohols, which are a white powder, soluble in water, glycerine and glycol. The polyvinyl alcohol is condensed on heating with saturated and unsaturated aldehyde, and also with their polymers or derivatives, for example, acetol, obtained from acetylene and methyl alcohol.



By this means may be obtained a great range of various transparent, absolutely fast to light products, from rubber-like and flexible to the hard and brittle, depending upon the constituent materials and the conditions of the condensation.

These substances, known under the general term of polyvinylacetals, by themselves, as well as after the treatment with suitable plasticizers, find wide application for the preparation of film-forming agents, impregnating binding media, articles for electrotechnology and household; they are distinguished by exceptionally strong adhesive properties and form valuable technical cements, for example, for bonding lenses of safety glass.

(To be continued.)

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